# 1.1 Outdoor Air Quality

Among the pollutants affecting outdoor air quality are:

- Criteria pollutants–ozone ($O_3$), particulate matter (PM), sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), carbon monoxide (CO), and lead.
- Air toxics–pollutants such as mercury and benzene.

Under the Clean Air Act, EPA and states collect data on the six criteria air pollutants to measure compliance with National Ambient Air Quality Standards (NAAQS) (Exhibit 1-3). "Primary" NAAQS are set to protect public health with an adequate margin of safety, and "secondary" NAAQS protect against adverse welfare effects (e.g., effects on vegetation, ecosystems, visibility, manmade materials) (42 U.S.C. 7408 and 7409). After initially adopting NAAQS for each of the criteria air pollutants in the 1970s, EPA has periodically reviewed and sometimes revised the standards. EPA recently revised the health-based standard for ozone and added a new standard for fine $PM_{2.5}$ based on new health studies (EPA, 2003; EPA, 1997).

Criteria air pollutants are monitored through the National Air Monitoring Stations/State or Local Air Monitoring Stations network. This network consists of more than 5,000 monitors operating at 3,000 sites across the country, mostly in urban areas (EPA, OAQPS, September 2002). Measurements are taken on both a daily and continuous basis to assess both peak concentrations and overall trends, and are reported in the Air Quality Subsystem (AQS) database. In addition to other uses, EPA analyzes these air quality measurements to designate areas as either attainment or nonattainment for specific criteria air pollutants (i.e., determines if air quality levels in an area violate the NAAQS).

While air quality data on criteria air pollutants are ample, national data on air toxics concentrations are limited. Several metropolitan areas measure ambient air toxics concentrations, but there are few standards by which to evaluate levels of concern. In addition, cumulative or synergistic impacts of various air pollutants are not well understood.

Visibility is another outdoor air concern. Some data on this aspect of air quality are available from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, which collects data to characterize visibility at national parks and other protected areas.

This section addresses the following specific questions about outdoor air quality:

- What is the quality of outdoor air in the United States? (Section 1.1.1)
  - How many people are living in areas with particulate matter and ozone levels above the NAAQS?

## Exhibit 1-3: National Ambient Air Quality Standards (NAAQS) in effect as of February 2003

| Pollutant | Primary Standard (Health Related) | | Secondary Standard (Welfare Related) | |
|---|---|---|---|---|
| | Type of Average | Standard Level Concentration[a] | Type of Average | Standard Level Concentration |
| CO | 8-hour[b]<br>1-hour[b] | 9 ppm (10 mg/m$^3$)<br>35 ppm (40 mg/m$^3$) | No Secondary Standard<br>No Secondary Standard | |
| Pb | Maximum Quarterly Average | 1.5 µg/m$^3$ | Same as Primary Standard | |
| $NO_2$ | Annual Arithmetic Mean | 0.053 ppm (100 µg/m$^3$) | Same as Primary Standard | |
| $O_3$ | Maximum Daily 1-hour Average[c]<br>4th Maximum Daily[d] 8-hour Average | 0.12 ppm (235 µg/m$^3$)<br>0.08 ppm (157 µg/m$^3$) | Same as Primary Standard<br>Same as Primary Standard | |
| $PM_{10}$<br><br>$PM_{2.5}$ | Annual Arithmetic Mean<br>24-hour[e]<br>Annual Arithmetic Mean[f]<br>24-hour[g] | 50 µg/m$^3$<br>150 µg/m$^3$<br>15 µg/m$^3$<br>65 µg/m$^3$ | Same as Primary Standard<br>Same as Primary Standard<br>Same as Primary Standard<br>Same as Primary Standard | |
| $SO_2$ | Annual Arithmetic Mean<br>24-hour[b] | 0.03 ppm (80 µg/m$^3$)<br>0.14 ppm (365 µg/m$^3$) | 3-hour[b] | 0.50 ppm (1,300 µg/m$^3$) |

a Parenthetical value is an approximately equivalent concentration. (See 40 CFR Part 50).

b Not to be exceeded more than once per year.

c The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than one, as determined according to Appendix H of the Ozone NAAQS.

d Three-year average of the annual 4th highest daily maximum 8-hour concentration.

e The short-term (24-hour) standard of 150 µg/m$^3$ is not to be exceeded more than once per year on average over three years.

f Spatially averaged over designated monitors.

g The form is the 98th percentile.

Source: Based on EPA, Office of Air Quality Planning and Standards. *National Air Quality and Emissions Trends Report, 1999*. March 2001.

- ▲ What are the concentrations of some criteria air pollutants: $PM_{2.5}$, $PM_{10}$, ozone, and lead?
- ▲ What are the impacts of air pollution on visibility in national parks and other protected lands?
- ▲ What are the concentrations of toxic air pollutants in ambient air?

■ What contributes to outdoor air pollution? (Section 1.1.2)
- ▲ What are contributors to particulate matter, ozone, and lead in ambient air?
- ▲ What are contributors to toxic air pollutants in ambient air?
- ▲ To what extent is U.S. air quality the result of pollution from other countries, and to what extent does U.S. air pollution affect other countries?

■ What human health effects are associated with outdoor air pollution? (Section 1.1.3)

■ What ecological effects are associated with outdoor air pollution? (Section 1.1.4)

## 1.1.1 What is the quality of outdoor air in the United States?

### Indicator

Number and percentage of days that metropolitan statistical areas (MSAs) have Air Quality Index (AQI) values greater than 100

The nation's air quality has generally improved, as indicated by trends derived by averaging the direct measurements from the nation's criteria air pollutant monitoring stations on a yearly basis. In general, air pollution concentrations are declining, and overall air quality is improving (EPA, OAQPS, September 2002).

Most areas of the U.S. now have concentrations of $NO_2$, $SO_2$, CO, and lead that are below the level of the NAAQS (EPA, OAQPS, September 2002). However, ozone levels are above the level of the standard in many heavily populated areas, including many of the urban areas in the eastern half of the U.S. and in most of the urban areas in California (EPA, OAQPS, March 2001). Concentrations of $PM_{2.5}$—particles less than or equal to 2.5 micrometers in diameter—are above the level of the standard in much of the eastern U.S. and parts of California (EPA, OAQPS, September 2002).

It is important to recognize that while the national trend is toward cleaner air, regional and local conditions can vary quite greatly. This report focuses on national status and trends, but regional and local conditions should be evaluated as well, with the goal of understanding regional air quality conditions and trends and improving air quality in those areas where air quality does not meet the standards.

A number of indicators, described on the following pages, help to answer the questions posed in this section about outdoor air quality:

- ■ Number and percentage of days that Metropolitan Statistical Areas (MSAs) have Air Quality Index (AQI) values greater than 100
- ■ Number of people living in areas with air quality levels above the NAAQS for particulate matter and ozone
- ■ Ambient concentrations of particulate matter: $PM_{2.5}$ and $PM_{10}$
- ■ Ambient concentrations of ozone: 8-hour and 1-hour
- ■ Ambient concentrations of lead
- ■ Visibility
- ■ Ambient concentrations of selected air toxics
- ■ Emissions of particulate matter ($PM_{2.5}$ and $PM_{10}$), sulfur dioxide, nitrogen oxides, and volatile organic compounds
- ■ Lead emissions
- ■ Air toxics emissions

## Indicator: Number and percentage of days that metropolitan statistical areas (MSAs) have Air Quality Index (AQI) values greater than 100 - Category 2

One measure of outdoor air quality is the daily AQI, which is based on concentrations of five of the criteria air pollutants: ozone, PM, CO, $SO_2$, and $NO_2$. The AQI indicates how clean or polluted the air is and the associated health concerns. It focuses on the health effects that can occur within a few hours or days after breathing polluted air. AQI data are compiled by state and local agencies and must be reported in metropolitan statistical areas (MSAs) with populations of more than 350,000 (EPA, OAQPS, March 2001).

AQI values range from 0 to 500, with higher numbers indicating more air pollution and more potential risk to public health. An AQI value of 100 generally corresponds to the short-term public health standard set by EPA for a particular pollutant. Values below 100 are generally thought of as satisfactory. However, unusually sensitive individuals may experience health effects when AQI values are between 50 and 100. Values above 100 suggest increasingly unhealthy air; sensitive population groups, such as children, the elderly, and those with respiratory illnesses, are likely to be among the first affected as the values increase.

The AQI scale is divided into six categories, each color-coded to correspond to a different level of health concern. For example,

- The color green is associated with "good" air quality or an AQI from 0 to 50.
- Yellow or "moderate"—51 to 100.
- Orange or "unhealthy for sensitive groups"—101 to 150.
- Red or "unhealthy"—151 to 200.
- Purple or "very unhealthy"—201 to 300.
- Maroon or "hazardous"—301 to 500. AQI values over 300 would trigger health warnings of emergency conditions for the entire population (EPA, OAQPS, March 2001).

The highest AQI value for an individual pollutant becomes the AQI value for that area for that particular day. For example, if on a day a certain area had AQI values of 150 for ozone and 120 for PM, the AQI value would be 150 for the pollutant ozone on that day. However, for all pollutants above 100, the appropriate sensitive groups would be cautioned. Ozone levels most often drive the AQI, but experts anticipate that $PM_{2.5}$ will also be a key driver of the AQI in coming years.

The AQI is useful in communicating to the public the air quality in a specific area on a given day and the potential health effects and actions to avoid exposure and reduce harmful impacts. Nationally, the number and percentage of days with AQI values of more than 100 gives a sense of the number of days that are potentially unhealthy for sensitive populations.

### What the Data Show

This indicator is the annual sum of the number of days, and percentage of days, with AQI values above 100 across all MSAs with a population greater than 500,000. To assess trends, the number of days is adjusted to reflect changes in air quality standards or criteria for the number of MSAs reporting.

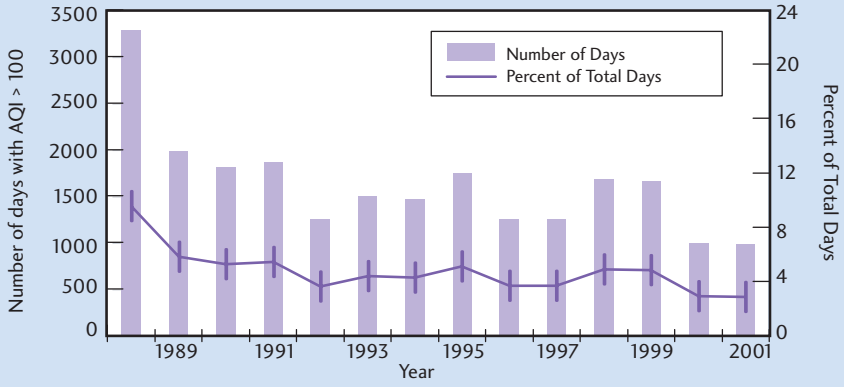
Between 1988 and 2001, the number of days with an AQI of 100 or greater decreased from approximately 3,300 days to approximately 1,000 days. In 1989 and after, the number of days with an AQI of 100 or greater ranged between 1,000 and 2,000. Based on EPA AQI data, the percentage of days across the country with AQI values above 100 dropped from almost 10 percent in 1988 to 3 percent in 2001 (Exhibit 1-4) (EPA, OAQPS, December 1998; EPA, OAQPS, 2001).

### Indicator Gaps and Limitations

Limitations of this indicator include the following:

- The data for this indicator are associated with large MSAs only (500,000 people or more); therefore, the data tend to reflect urban air quality.

Exhibit 1-4: Number and percentage of days with Air Quality Index (AQI) greater than 100, 1988-2001




Note: Data are for MSAs > 500,000

Source: Data used to create graphic are drawn from EPA, Office of Air Quality Planning and Standards. *National Air Quality and Emissions Trends Report*, 1997. Table A-15. December, 1998; EPA, Office of Air Quality Planning and Standards. Air trends: Metropolitan area trends, Table A-17, 2001. (February 25, 2003; *http://www.epa.gov/airtrends/metro.html*).

Indicator

## Number and percentage of days that metropolitan statistical areas (MSAs) have Air Quality Index (AQI) values greater than 100 - Category 2 (continued)

- This composite AQI indicator does not identify the pollutants of concern–that is, it does not show which pollutant(s) are causing the days with an AQI of more than 100, or which ones have decreased and are responsible for an improvement in the AQI.
- This composite AQI indicator does not show which areas, or how many areas, have problems–a specific number of days could reflect a few areas with persistent problems or many areas with occasional problems.

### Data Source

The data sources for this indicator were "Air Trends: Metropolitan area trends," Table A-17, EPA, 2001, and *National Air Quality and Emissions Trends Report, 1997*, Table A-15, EPA, 1998. (See Appendix B, page B-2, for more information.)

# 1.1.1.a How many people are living in areas with particulate matter and ozone levels above the National Ambient Air Quality Standards (NAAQS)?

In 2001, more than 133 million Americans (of a total population of 281 million) lived in counties where monitored outdoor air quality was unhealthy at times because of high levels (levels above the NAAQS) of at least one criteria air pollutant (EPA, OAQPS, September 2002). Ozone and PM remain the most persistent criteria pollutants.

**Indicator**

Number of people living in areas with air quality levels above the NAAQS for particulate matter (PM) and ozone

Indicator

## Number of people living in areas with air quality levels above the NAAQS for particulate matter (PM) and ozone - Category 1

The number of people living in areas above the level of the health-based NAAQS gives some indication of the number of people potentially exposed to unhealthy air.

### What the Data Show

Despite trends of decreasing concentrations of criteria pollutants, many people still live in areas with air quality levels above the health-based standards for ozone and PM. In 2001, 11.1 million people lived in counties with air quality concentrations that at times were above the NAAQS for $PM_{10}$, and 72.7 million people lived in counties with air quality concentrations above the standard for $PM_{2.5}$. Some 40.2 million people lived in counties with concentrations that at times were above the 1-hour ozone standard, and 110.3 million people lived in counties with concentrations above the 8-hour ozone standard (Exhibit 1-5) (EPA, OAQPS, September 2002).

### Indicator Gaps and Limitations

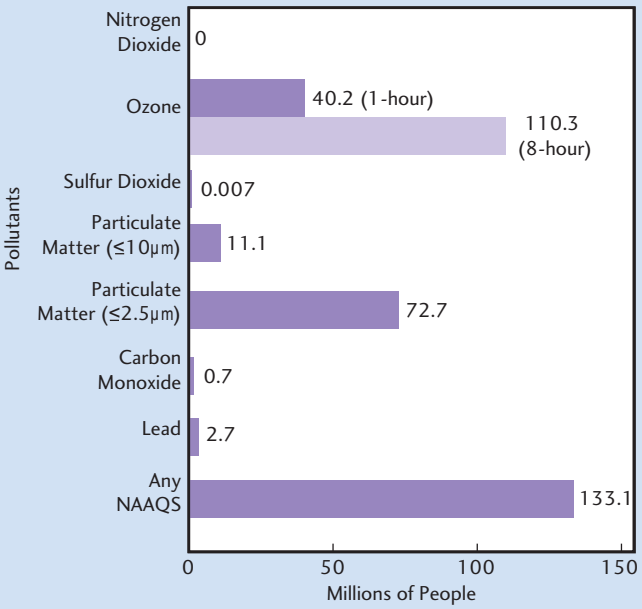
Limitations of this indicator include the following:

- The indicator helps in understanding the number of people potentially affected by air quality problems, but it does not tell the actual number of people exposed to unhealthy air. Not all counties have complete monitoring data, so some areas may be excluded. However, the areas of most concern are likely covered.

Indicator

## Number of people living in areas with air quality levels above the NAAQS for particulate matter (PM) and ozone - Category I (continued)

Exhibit 1-5: People living in areas with air quality above the National Ambient Air Quality Standards (NAAQS) in 2001




Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

- The indicator does not tell the amount or extent to which different areas exceed the standards, and so does not provide any specific exposure data.

### Data Sources

The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-3, for more information.)

# 1.1.1.b What are the concentrations of some criteria air pollutants: $PM_{2.5}$, $PM_{10}$, ozone, and lead?

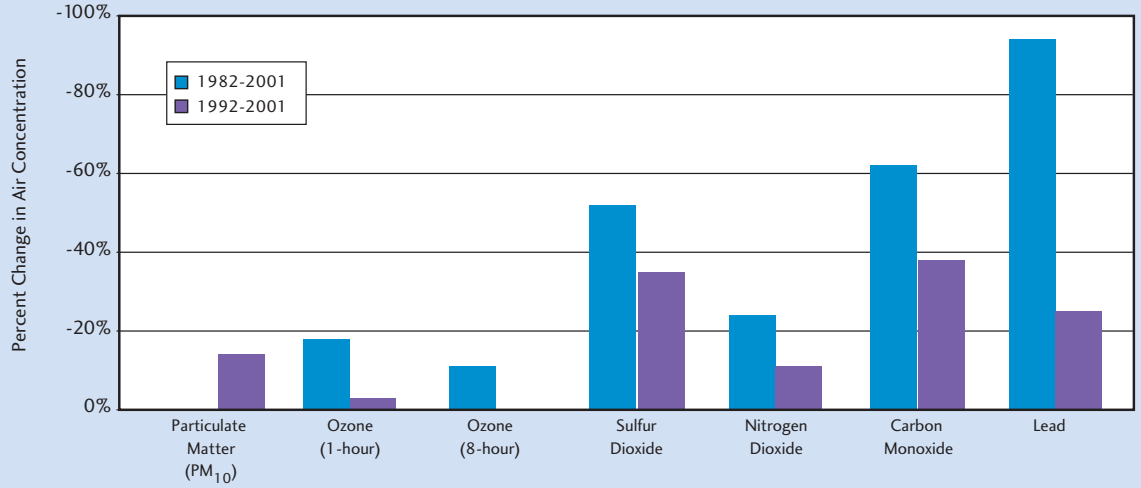
### Indicators

Ambient concentrations of particulate matter: $PM_{2.5}$ and $PM_{10}$
Ambient concentrations of ozone: 8-hour and 1-hour
Ambient concentrations of lead

Three indicators, presented on the following pages, are available to help answer this question: ambient concentrations of particulate matter, ambient concentrations of ozone (8-hour and 1-hour), and ambient concentrations of lead. Concentrations of the criteria air pollutants have decreased over the past 2 decades, with substantial reductions in $SO_2$, CO, and lead levels (Exhibit 1-6) (EPA, OAQPS, September 2002). However, $PM_{2.5}$ and ozone concentrations are above the NAAQS in many areas, potentially exposing a significant percentage of the U.S. population to unhealthy air (EPA, OAQPS, September 2002).

The data for national levels of criteria pollutants tell only part of the story. Although significant improvements have been occurring nationally and regionally, some areas still have chronic air quality problems. The Northeast, for example, experiences frequent and widespread violations of the ozone health-based standard (Northeast States for Coordinated Air Use Management, 2002).

Exhibit 1-6: Percent reduction in concentration of six criteria air pollutants regulated under the Clean Air Act, 1982-2001




Note: Trend data for $PM_{2.5}$ are not available. Trend data for $PM_{10}$ are only available for 1992-2001. Between 1992-2001, ozone (8-hour) concentrations remained level.

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

## Indicator: Ambient concentrations of particulate matter: $PM_{2.5}$ and $PM_{10}$- Category I

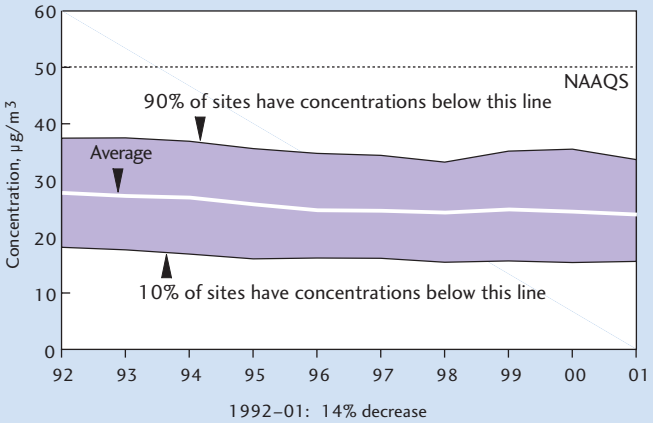
Particulate matter concentrations are a good indication of air quality health effects, because of concerns about associated respiratory effects. This indicator is based on the annual average concentrations, in micrograms per cubic meter ($\mu g/m^3$) of $PM_{2.5}$ and $PM_{10}$. $PM_{10}$ refers to particles 10 micrometers or less in diameter, and $PM_{2.5}$ refers to particles less than or equal to 2.5 micrometers in diameter.

Trends in $PM_{10}$ are presented from 1992 to 2001, and comparable $PM_{2.5}$ data have been collected since 1999 (EPA, OAQPS, September 2002).

### What the Data Show

Concentrations of $PM_{10}$ decreased by 14 percent between 1992 and 2001 (Exhibit 1-7), and are below the NAAQS standard concentration in most areas. Concentrations of $PM_{2.5}$ are above the level of the annual standard in much of the eastern U.S. and parts of California (Exhibit 1-8) (EPA, OAQPS, September 2002). Annual average $PM_{2.5}$ concentrations are generally higher in the eastern U.S. than in the West, mostly because sulfate concentrations are four to five times higher in the eastern U.S. (largely due to coal-fired power plants) (EPA, OAQPS, September 2001).

Exhibit 1-7: Particulate matter ($PM_{10}$) air quality, 1992-2001
based on seasonally weighted annual average




Coverage: 770 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

Indicator: Ambient concentrations of particulate matter: $PM_{2.5}$ and $PM_{10}$- Category I (continued)

## Indicator Gaps and Limitations

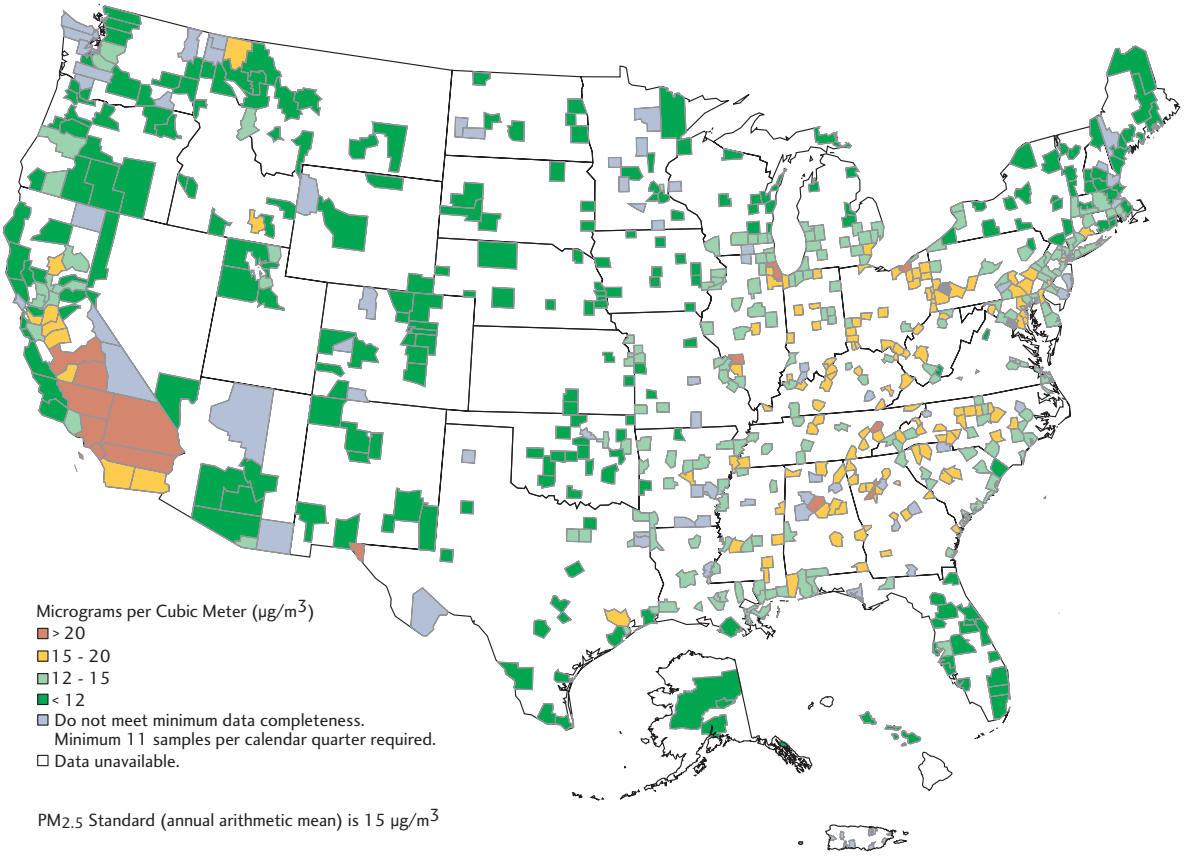
Limitations of this indicator include the following (EPA, OAQPS, September 2002):

- Ten-year trend data for PM10 are not available before 1990, because total suspended particulates, which include particle sizes larger than PM10, were monitored until 1990.
- The monitoring is conducted mostly in urban areas, although the PM2.5 data from the IMPROVE network support assessments of rural trends from 1992 to 1999.

## Data Source

The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-3, for more information.)

Exhibit I-8: 2001 annual average particulate matter ($PM_{2.5}$) concentrations




Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends.* September 2002.

Indicator

# Ambient concentrations of ozone: 8-hour and 1-hour - Category I

Ozone is one of six criteria pollutants regularly monitored under the CAA to determine compliance with health-based standards. This indicator reflects ambient concentrations in parts per million (ppm) of ground- level ozone from 1982 to 2001, based on 1-hour and 8-hour measurements to gauge shorter-term and longer-term levels.

The 1-hour standard is useful in measuring potential effects during short-term "spikes" in concentrations. The longer 8-hour standard is used in evaluating exposures occurring over a more sustained period of time (e.g., an outdoor worker's exposure over the course of a work day).

## What the Data Show

Although ozone concentrations are generally decreasing, they are higher than the NAAQS in many areas. Ground-level ozone concentrations fell by 11 percent between 1982 and 2001, based on the annual fourth highest daily maximum 8-hour average (Exhibit 1-9). Ozone levels based on the annual second highest daily maximum 1-hour standard fell by 18 percent during the same time (Exhibit 1-10). All regions experienced some improvement in 8-hour ozone levels during the past 20 years except the north central region (EPA Region 7), which showed little change (Exhibit 1-11) (EPA, OAQPS, September 2002).

## Indicator Gaps and Limitations

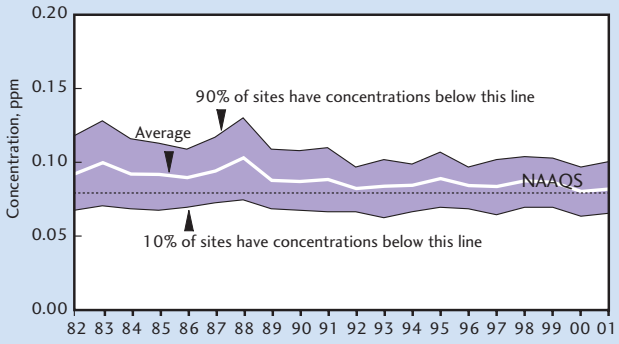
Limitations of this indicator include the following:

- Ground-level ozone is not emitted directly into the air, but is formed by the reaction of volatile organic compounds (VOCs) and nitrogen oxides ($NO_X$) in the presence of heat and sunlight, particularly in hot summer weather. To assess ozone trends, VOC and $NO_X$ emissions and meteorological information are also evaluated.
- The monitoring is conducted mostly in urban areas; therefore, data may not accurately encompass rural impacts from ozone transport.

## Data Source

The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-3, for more information.)

### Exhibit 1-9: Ozone air quality, 1982-2001
based on annual 4th maximum 8-hour average

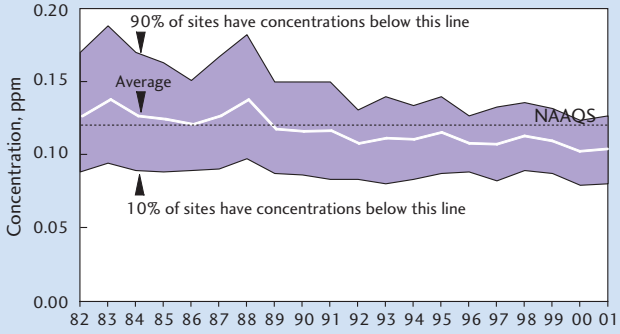



1982–01: 11% decrease
1992–01: 0% change

Coverage: 379 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality:* 2001 Status and Trends. September 2002.

### Exhibit 1-10: Ozone air quality, 1982-2001
based on annual 2nd maximum 1-hour average



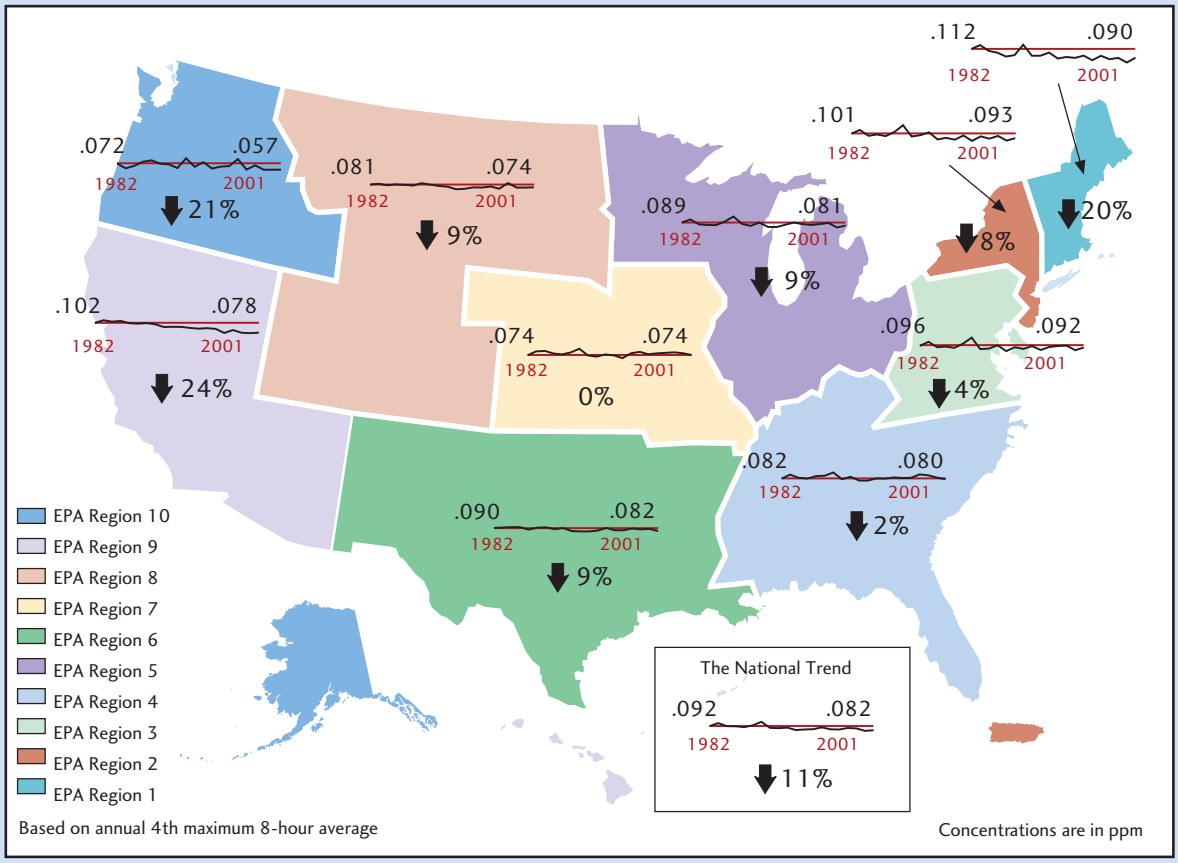

1982–01: 18% decrease
1992–01: 3% decrease

Coverage: 379 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends.* September 2002.

## Indicator: Ambient concentrations of ozone: 8-hour and 1-hour - Category I (continued)

Exhibit 1-11: Trends in ozone levels (8-hour), 1982-2001, averaged across EPA regions




Note: Alaska levels are included in EPA region 10 averages; Hawaii levels are included in EPA region 9 averages; and Puerto Rico levels are included in EPA region 2 averages.

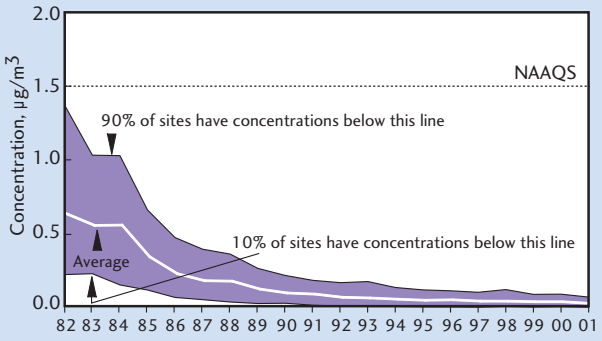
Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

Indicator

## Ambient concentrations of lead - Category I

Lead is a metal found naturally in the environment as well as in manufactured products. The major sources of lead emissions have historically been motor vehicles and industrial sources. Due to the phase-out of leaded gasoline, metals processing is the major source of lead emissions to the air today. The highest air concentrations of lead are usually found in the vicinity of smelters and battery manufacturers. Lead is a criteria and toxic air pollutant with significant health effects, as described in Chapter 4, Human Health.

Exhibit 1-12: Lead air quality, 1982-2001
Based on annual maximum quarterly average




1982–01: 94% decrease
1992–01: 25% decrease

Coverage: 39 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

### What the Data Show

This indicator shows ambient lead concentrations measured in µg/m$^3$ per year from 1982 to 2001. Lead levels decreased by 94 percent in those years, largely because of regulations reducing the lead content in gasoline (Exhibit 1-12) (EPA, OAQPS, September 2002). The most significant decline in ambient lead levels began in the late 1970s and continued through the early 1980s. Outdoor lead levels are below the NAAQS for most areas of the U.S. (EPA, OAQPS, September 2002).

### Indicator Gaps and Limitations

Limitations of this indicator include the following:

- Ambient lead monitoring is conducted mostly in urban areas, so it may not accurately encompass rural concentrations.
- This indicator would be very useful in conjunction with indicators of lead concentration in indoor air, drinking water, and soil to portray a broad picture of potential sources of lead exposure.

### Data Source

The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-4, for more information.)

# 1.1.1.c What are the impacts of air pollution on visibility in national parks and other protected lands?

## Indicator

Visibility

Visibility is a measure of aesthetic value and the ability to enjoy scenic vistas, but it also can be an indicator of general air quality. PM is the major contributor to reduced visibility, and high humidity levels worsen the effects of pollution on visibility. The Interagency Monitoring of Protected Visual Environments (IMPROVE) network collects data to characterize visibility in protected lands. IMPROVE was established in 1987 to:

- Determine the type of pollutants primarily responsible for reduced visibility in protected areas.
- Assess progress toward the Clean Air Act's national goal of remedying existing and preventing future visibility impairment.

The indicator below presents data from the IMPROVE network on visibility trends for national parks and other protected lands.

# Indicator: Visibility - Category I

This indicator presents visibility trends for U.S. national parks and wilderness areas in the eastern and western U.S. by mean visual range, as measured in km for 1992 to 1999 and 1990 to 1999, respectively, by worst, mid-range, and best visibility. Under the Clean Air Act, a Class I area is one in which visibility is protected more stringently than under the NAAQS, including national parks, wilderness areas, monuments, and other areas of special national and cultural significance.

## What the Data Show

Data collected by the IMPROVE network show that visibility for the worst visibility days in the West is similar to days with the best visibility in the East (Exhibit 1-13). In 1999, the mean visual range for the worst days in the East was only 24 km (14.9 miles) compared to 84 km (52.2 miles) for the best visibility. In the West, visibility impairment for the worst days remained relatively unchanged over the 1990s, with the mean visual range for 1999 (80 km or 49.7 miles) nearly the same as the 1990 level (86 km or 53.4 miles). Without the effects of pollution, a natural visual range in the U.S. is approximately 75 to 150 km (47 to 93 miles) in the East and 200 to 300 km (124 to 186 miles) in the West (EPA, OAQPS, September 2002).

## Indicator Gaps and Limitations

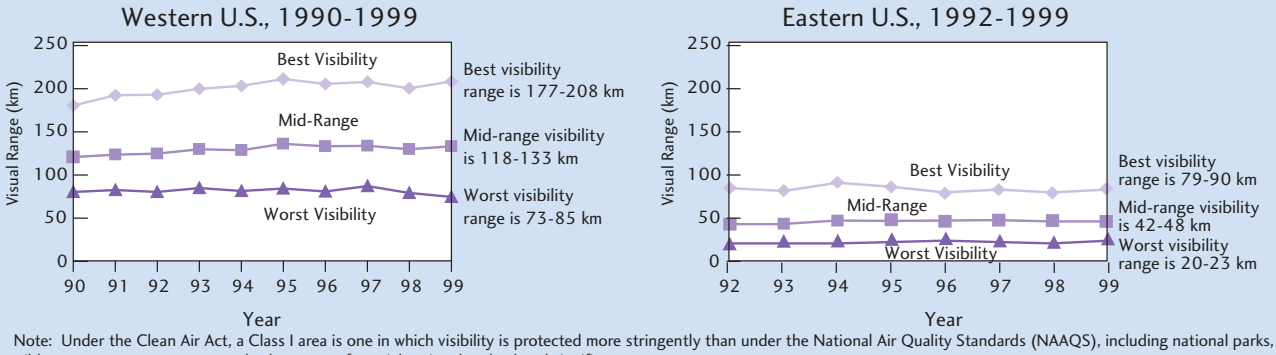
Limitations of this indicator include the following:

- The indicator compares trends within visibility range categories, but it would also be useful to indicate how often visibility falls into each range during a year.
- The data represent only a sampling of national park and wilderness areas; nevertheless, this indicator provides a good picture of the impact of air pollution on the nation's parks and protected areas. As of 2001, the network monitored 110 sites.

## Data Source

The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-4, for more information.)

### Exhibit 1-13: Visibility trends for U.S. Class I areas




Note: Under the Clean Air Act, a Class I area is one in which visibility is protected more stringently than under the National Air Quality Standards (NAAQS), including national parks, wilderness areas, monuments, and other areas of special national and cultural significance.

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

# 1.1.1.d What are the concentrations of toxic air pollutants in ambient air?

## Indicator
Ambient concentrations of selected air toxics

Air toxics, also known as hazardous air pollutants, are pollutants that may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. The Clean Air Act identifies 188 air toxics; some common ones are perchloroethylene (from dry cleaners), mercury (from coal combustion), methylene chloride (from consumer products such as paint strippers), and benzene and 1,3-butadiene (from gasoline). EPA does not set health-based standards for these pollutants; instead, the Clean Air Act mandates a two-phased approach. In the first phase, EPA establishes standards for source categories (major sources, area sources, and mobile sources). In the second phase, EPA assesses how well the standards are reducing health and environmental risks, and based on these assessments, determines what further actions are necessary to address any significant remaining, or residual, health or environmental risks.

No formal monitoring network for air toxics currently exists, but several metropolitan areas do maintain monitoring programs. Data from these areas provide the basis for an air toxics indicator. Metropolitan areas with air toxics data generally show downward trends (EPA, OAQPS, September 2002). However, although data and tools for assessing risks from air toxics are limited, available evidence suggests that emissions of air toxics may still pose significant health risks in many areas throughout the U.S. (EPA, OAR, September 2002). In addition to ambient concentrations of air toxics, an issue of particular concern is the deposition of toxic air pollutants to surface waterbodies. A pollutant of particular concern is mercury, which accumulates in fish tissue and in humans after they ingest contaminated fish (see Chapter 2, Purer Water; and Chapter 5, Ecological Condition).

## Indicator: Ambient concentrations of selected air toxics - Category 2

This indicator reflects data about annual average ambient concentrations of four selected air toxics, in μg/m³, derived from monitoring sites with sufficient trend data from 1994 to 1999. Selected air toxics are benzene, 1,3-butadiene, total suspended lead, and perchloroethylene (EPA, OAQPS, March 2001).

### What the Data Show

Ambient concentrations of the selected air toxics—benzene, 1,3-butadiene, total suspended lead, and perchlorethylene—generally declined between 1994 and 1999, based on the annual average from the reporting sites (EPA, OAQPS, March 2001). The lead concentration level is well below the NAAQS standard (see Section 1.1.1.b in this chapter). Benzene levels, measured at 95 urban monitoring sites, decreased 47 percent from 1994 to 2000 (Exhibit 1-14) (EPA, OAQPS, September 2002).

### Indicator Gaps and Limitations

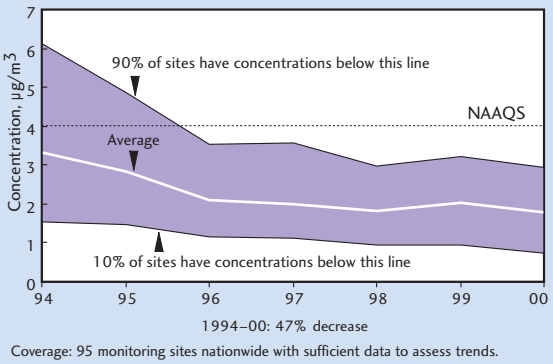
Limitations of this indicator include the following:

- Information is limited because no formal network is currently in place for monitoring ambient concentrations of air toxics; however, EPA and states are working to establish a national toxics monitoring network.
- The indicator reflects trends for selected air toxics, but not for all 188 toxic air pollutants identified under the CAA.
- More information is available for lead than for the other three selected air toxics. Monitoring stations with sufficient trend data for the other three compounds tend to be concentrated in California, the Great Lakes, southern Texas, and the Northeast.

### Data Sources

The data sources for this indicator were *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002, and *National Air Quality and Emissions Trends Report, 1999*, EPA, 2001. (See Appendix B, page B-4, for more information.)

Exhibit 1-14: Ambient benzene, annual average urban concentrations, nationwide, 1994-2000




Coverage: 95 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

## 1.1.2 What contributes to outdoor air pollution?

Anthropogenic sources of air pollution range from "stationary sources" such as factories, power plants, agricultural facilities, and smelters, to smaller "area sources" such as dry cleaners and degreasing operations, to "mobile sources" such as cars, buses, planes, trucks, trains, construction equipment, and lawn mowers. Naturally occurring sources such as wind-blown dust, volcanoes, and wildfires add to the total air pollution burden and may be significant on local and regional scales.

Most of the six criteria air pollutants show declining emissions since 1982. But as reported in *Latest Findings on National Air Quality: 2001 Status and Trends*, emissions of $NO_X$, a contributor to ozone, PM, and acid rain formation, increased by nine percent between 1982 and 2001, with a slight decrease (three percent) between 1992 and 2001 (EPA, OAQPS, September 2002). A significant amount of that increase is attributed to growth in emissions from non-road engines, including construction and recreation equipment and diesel vehicles. EPA continuously reviews and improves estimates of pollutant emissions. Emissions estimates for criteria pollutants are currently under such evaluation and may be updated.

## 1.1.2.a What are contributors to particulate matter, ozone, and lead in ambient air?

### Indicators

Emissions: particulate matter ($PM_{2.5}$ and $PM_{10}$), sulfur dioxide, nitrogen oxides, and volatile organic compounds
Lead emissions

Two indicators are available to help answer this question:

- Emissions of particulate matter, sulfur dioxide, nitrogen oxide, and volatile organic compounds.
- Emissions of lead.

Particulate matter can be emitted directly or formed in the atmosphere. "Primary" particles, such as dust from roads and elemental carbon (soot) from wood combustion, are emitted directly into the atmosphere. "Secondary" particles are formed in the atmosphere from primary gaseous emissions. Examples include sulfates, formed from $SO_2$ emissions from power plants and industrial facilities, and nitrates, formed from $NO_X$ emissions from power plants, automobiles, and other types of combustion sources. The chemical composition of particles depends on factors such as location, time of year, and weather.

The VOCs contributing to ozone formation are emitted from motor vehicles, chemical plants, refineries, factories, consumer and commercial products such as paints and strippers, and other industrial sources. Nitrogen oxides, also an ozone precursor, are emitted primarily from vehicles, power plants, and other combustion sources. Smelters and battery manufacturers are the largest sources of lead in outdoor air.

Indicator

# Emissions: particulate matter ($PM_{2.5}$ and $PM_{10}$), sulfur dioxide, nitrogen oxides, and volatile organic compounds - Category 2

This indicator includes the following data:

- Direct PM emissions are measured in thousands of short tons per year. $PM_{10}$ emissions are presented from 1985 to 2001; emissions of $PM_{2.5}$ from 1992 to 2001.
- Emissions of $NO_X$, and $SO_2$ presented from 1982 to 2001. Emissions of $NO_X$, contribute to nitrogen loading on land and in water directly and as runoff from land. $NO_X$, is also a precursor of ground-level ozone. Sulfates and nitrates, formed by emissions of $SO_2$ and $NO_X$, contribute to acid deposition, which can have significant impacts on aquatic life (see Chapter 2, Purer Water).
- Emissions of VOCs, also precursors of ground-level ozone. These emissions, presented from 1982 to 2001, are measured in thousands of short tons per year.

## What the Data Show

Direct emissions of $PM_{10}$ fell by 13 percent between 1992 and 2001 (Exhibit 1-15). Emissions of direct $PM_{2.5}$ also fell, decreasing by 10 percent between 1992 and 2001 (Exhibit 1-16). Sulfur dioxide emissions also decreased by 25 percent between 1982 and 2001 and by 24 percent between 1992 and 2001 (Exhibit 1-17). However, emissions of $NO_X$ increased by 9 percent between 1982 and 2001 and decreased by 3 percent between 1992 and 2001 (Exhibit 1-18) (EPA, OAQPS, September 2002). VOC emissions decreased by 16 percent from 1982 to 2001 and by 8 percent from 1992 to 2001 (Exhibit 1-19) (EPA, OAQPS, September 2002).

## Indicator Gaps and Limitations

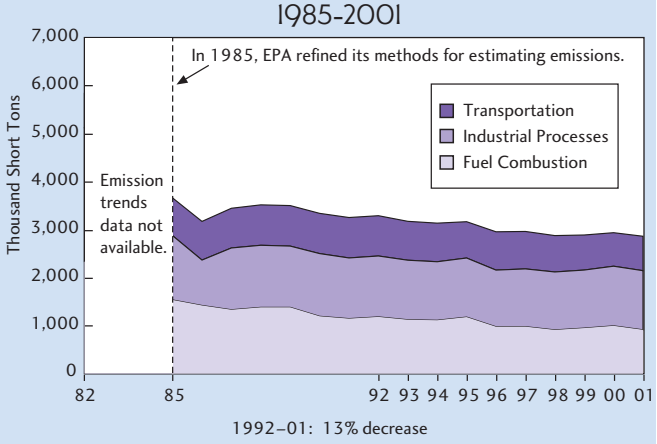
Limitations of this indicator include the following:

- The emissions indicators are estimates; however, consistent estimation methods can provide useful trend data.
- The methodology for estimating emissions is continually reviewed and is subject to revision. EPA is currently conducting such an evaluation of emissions data, and emissions estimates may be updated. Trend data prior to these revisions must be considered in the context of those changes.

## Data Source

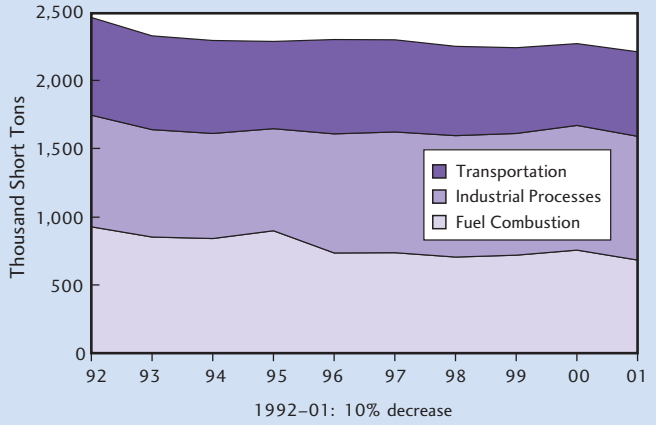
The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-5 for more information.)

Exhibit 1-15: Direct particulate matter ($PM_{10}$) emissions, 1985-2001




Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends.* September 2002.

Exhibit 1-16: Direct particulate matter ($PM_{2.5}$) emissions, 1992-2001

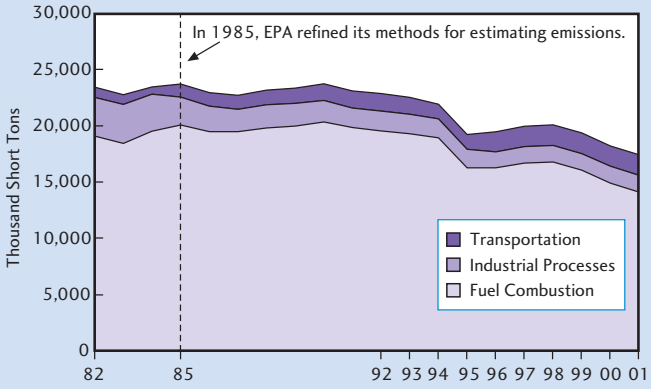



Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends.* September 2002.

## Indicator

Emissions: particulate matter ($PM_{2.5}$ and $PM_{10}$), sulfur dioxide, nitrogen oxides, and volatile organic compounds - Category 2 (continued)

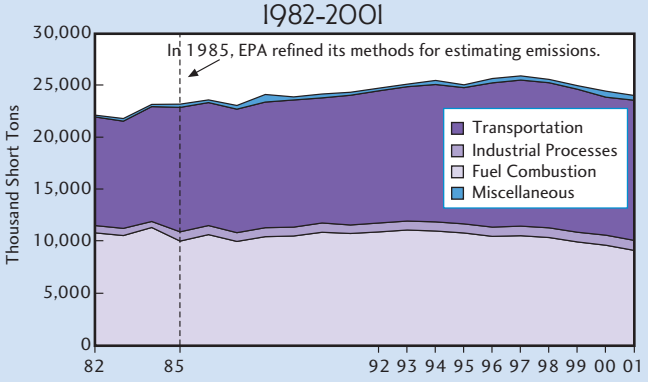
### Exhibit 1-17: Sulfur dioxide ($SO_2$) emissions, 1982-2001




1982–01: 25% decrease
1992–01: 24% decrease

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

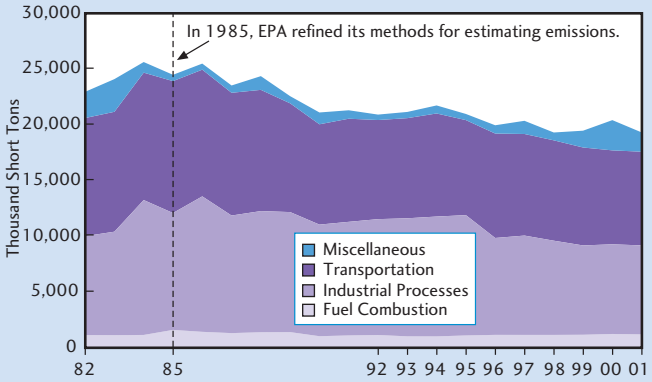
### Exhibit 1-18: Nitrogen oxides ($NO_x$) emissions, 1982-2001




1982–01: 9% increase
1992–01: 3% decrease

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

### Exhibit 1-19: Volatile organic compounds (VOCs) emissions, 1982-2001




1982–01: 16% decrease
1992–01: 8% decrease

Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

## Indicator: Lead Emissions - Category 2

This indicator is lead emissions from 1982 to 2001, measured in short tons per year.

### What the Data Show

Lead emissions decreased by 93 percent from 1982 to 2001 and by 5 percent from 1992 to 2001 (Exhibit 1-20) (EPA, OAQPS, September 2002). The transportation sector, particularly automotive sources, used to be the major source of lead emissions. The phase-out of lead in gasoline resulted in great declines in lead emissions from the transportation sector over the past 2 decades. Today, industrial processes, primarily metals processing, are the major source of lead emissions to the atmosphere.

### Indicator Gaps and Limitations

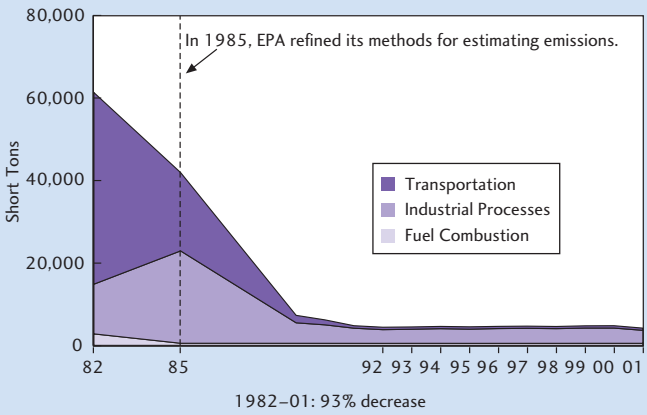
Limitations of this indicator include the following:

- The indicator does not present actual emissions data; thus, it has the inherent limitations of estimates. However, consistent estimation methods can provide useful trend data.
- Estimation is necessary for mobile sources and several area-wide sources.
- The methodology for estimating emissions is continually reviewed and is subject to revision. Trend data for years prior to revisions must be considered in the context of those changes.

### Data Source

The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-5, for more information.)

Exhibit 1-20: Lead emissions, 1982-2001




Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

# 1.1.2.b What are contributors to toxic air pollutants in ambient air?

## Indicator
Air toxics emissions

An indicator for air toxics emissions is available to help address this question. The Clean Air Act identifies 188 air toxics. EPA estimates that more than 50 percent of air toxics emissions come from vehicles and other mobile sources such as aircraft, locomotives, and construction equipment (EPA, OAQPS, September 2002). Other major sources include industrial facilities and area sources such as small dry cleaners and gas stations. Emissions of benzene, come from cars, trucks, oil refineries, and chemical processes. Mercury emissions come from coal combustion and waste incineration and can travel thousands of miles before being deposited in water or on land (see Chapter 2, Purer Water). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires.

## Indicator: Air toxics emissions - Category 2

This indicator is national air toxics emissions, in million of tons per year, between the 1990-1993 baseline period and 1996. EPA compiles an air toxics inventory as part of the National Emissions Inventory, which focuses on four sectors—large industrial sources, smaller industrial and natural sources, on-road mobile sources, and non-road mobile sources.

### What the Data Show

Estimates show a 24 percent reduction in nationwide air toxics emissions between the baseline period (1990-1993) and 1996—a reduction from 6.11 million to 4.67 million tons per year (Exhibit 1-21) (EPA, OAQPS, September 2002).

### Indicator Gaps and Limitations

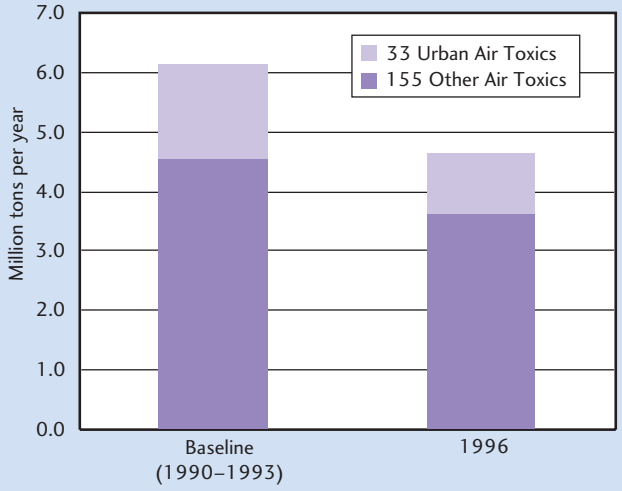
Limitations of this indicator include the following:

- Air toxics emissions estimates are currently available for only 1990 to 1993 (a mix of years depending on data availability on various source types) and 1996.
- The emissions data are based on estimates that are not available on an annual basis.
- The indicator is an aggregate number; actual changes vary among the toxic air pollutants and also vary from one part of the country to another.

### Data Source

The data source for this indicator was *Latest Findings on National Air Quality: 2001 Status and Trends*, EPA, 2002. (See Appendix B, page B-6, for more information.)

Exhibit 1-21: National air toxics emissions, 1990-1993, 1996 (total for 188 toxic air pollutants)




Source: EPA, Office of Air Quality Planning and Standards. *Latest Findings on National Air Quality: 2001 Status and Trends*. September 2002.

## 1.1.2.c To what extent is U.S. air quality the result of pollution from other countries, and to what extent does U.S. air pollution affect other countries?

Air pollution does not recognize political boundaries: ozone and PM, for example, can be transported hundreds or thousands of miles, depending on weather conditions, including wind speeds. Canada and the U.S. have jointly studied ground-level ozone occurrence and transport in eastern North America. Eight-hour ozone measurements for 1988 and 1995 from eastern Canada and the eastern U.S. demonstrate how ozone travels in both directions across the U.S.-Canadian border. The data suggested that ozone was being transported from urban to non-urban areas.

The U.S.-Canada Air Quality Committee studied the relative contribution of sources in each country to the ozone precursors–$NO_X$ and VOCs. According to the report, "anthropogenic sources of $NO_X$ emissions in the U.S. are ten times larger, and VOC emissions are 7 times larger in magnitude than in Canada, paralleling the relative population ratio between the 2countries." The study also showed that wind speed can significantly affect ozone transport between the two countries. At low wind speed (<3 meters per second), ozone concentrations were high over major metropolitan areas or close to the sources. At intermediate wind speeds (3 to 6 meters per second), overall concentrations were lower and ozone was transported up to 500 km downwind. At higher wind speeds, higher concentrations were in downwind corners up to 1,000 km away (U.S.-Canada Air Quality Committee, March 1999).

Transboundary air pollution issues are not limited to North America, as demonstrated in the discussion of stratospheric ozone depletion (see Section 1.4 in this chapter). More recently, the U.N. Environment Programme suggested that the so-called Asian Brown Cloud, a 2-mile-thick blanket of pollution over part of South Asia, could travel halfway around the globe in a week (CNN, 2002).

No specific indicators have been identified at this time to address the issue of transboundary air pollution.

## 1.1.3 What human health effects are associated with outdoor air pollution?

Outdoor air pollution can cause a variety of adverse health effects. Exposure to air pollution can result in short-term health effects and can also contribute to or aggravate chronic conditions. One such condition is asthma, the leading chronic illness of children in the U.S. and a leading cause of school absenteeism. In 2000, asthma caused 465,000 hospitalizations and about 4,500 deaths in the U.S. (CDC, 2003). Other chronic conditions to which air pollution can contribute include lung cancer, asthma, respiratory disease, and cardiovascular disease.

Some of the criteria pollutants, including ozone, $NO_2$, and $SO_2$, are associated primarily with respiratory-related effects, including aggravation of asthma and other respiratory diseases and irritation of the lung and respiratory symptoms (e.g., cough, chest pain, difficulty breathing) (EPA, ORD, 1982,1986, August 1993, 1994). Carbon monoxide, on the other hand, primarily affects people with cardiovascular disease by reducing oxygen in the blood, leading to aggravation of angina (EPA, ORD, NCEA, 2000).

Short-term exposure to ozone has been linked to lung inflammation and increased hospital admissions and emergency room visits (EPA, ORD, NCEA, July 1996). Repeated short-term exposures to ozone may damage children's developing lungs and may lead to reduced lung function later in life; long-term exposures to high ozone levels are a possible cause of increased incidence of asthma in children engaged in outdoor sports (McConnell, et al., 2002). Efforts to control automobile traffic in Atlanta during the 1996 Summer Olympic Games were associated with a 28 percent reduction in peak daily ozone concentrations during the Games and a significantly lower rate of childhood asthma events (Friedman, et al., 2001).

When EPA introduced a new 8-hour ozone ambient standard in 1997, it estimated that meeting the standard would reduce the risk of significant decreases in children's lung functions (such as difficulty in breathing or shortness of breath) by about 1 million incidences per year and would result in thousands of fewer hospital admissions and visits for people with asthma (EPA, OAQPS, July 1997).

Exposure to airborne particulate matter is associated with a broader range of health problems, including respiratory-related and cardiovascular effects. For example, short-term exposures to PM may aggravate asthma and bronchitis and have been associated with heartbeat irregularities and heart attacks. PM exposures have been linked to increased school absences and lost work days, hospital admissions and emergency room visits, and even death from heart and lung diseases (EPA, ORD, NCEA, April 1996). Long-term exposures have also been linked to deaths from heart and lung diseases, including lung cancer (EPA, ORD, NCEA, 2002; Pope, et al., 2002).

When EPA established new $PM_{2.5}$ standards in 1997, it estimated that meeting the standard would save about 15,000 lives each year, especially among the elderly and those with existing heart and lung diseases. The Agency said the new standard would reduce hospital admissions by thousands each year; reduce risk of symptoms associated with chronic bronchitis by tens of thousands each year; and avoid hundreds of thousands of incidences of asthma each year (EPA, OAQPS, July 1997).

Lead, both a criteria pollutant and a toxic air pollutant, has significant health effects. Elevated blood lead levels are associated with behavioral problems, neurological effects, and lowered IQ (EPA, OAQPS, September 2002), The decrease in the average level of lead in children's blood reflects declines in ambient lead levels by 93 percent from 1982 to 2001—largely the result of regulations reducing lead content in gasoline (EPA, OAQPS, September 2002).

Toxic or hazardous air pollutants may cause many other less common but potentially hazardous health effects, including cancer and damage to the immune system, and neurological, reproductive, and developmental problems. Acute exposure to some air toxics can cause immediate death. Many of these pollutants can cause serious health damages even at relatively low concentrations. National emission standards have been established for eight of the 188 listed hazardous air pollutants: asbestos, mercury, beryllium, benzene, vinyl chloride, arsenic, radionuclides, and coke oven emissions.

The National-Scale Air Toxics Assessment, a nationwide analysis of air toxics, develops health risk estimates for 33 toxic air pollutants using computer modeling of the 1996 National Emissions Inventory air toxics data. Based on the assessment, chromium, benzene, and formaldehyde appear to pose the greatest nationwide carcinogenic risk (EPA, OAR, September 2002). Benzene exposure has been linked to increases in the risk of leukemia and multiple myeloma (EPA, OAQPS, July 1995).

No specific indicators have been identified at this time to address the health effects associated with outdoor air pollution. For additional discussion of air pollution and associated health effects, see Chapter 4, Human Health.

## 1.1.4 What ecological effects are associated with outdoor air pollution?

Outdoor air not only has the potential to affect human health, but also transports pollutants and deposits them onto soils or surface waters. There, the pollutants can cause ecological effects and damage to property. Ground-level ozone damages plants and crops. It interferes with the ability of plants to produce and store food, reducing overall plant health and the ability to grow and reproduce. The weakened plants are more susceptible to harsh weather, disease, and pests. Through its effects on plants, ozone also can pose risks to ecological functions such as water movement, mineral nutrient cycling, and habitats for various animal and plant species (see Chapter 5, Ecological Condition).

Airborne nitrogen species (including the criteria pollutants $NO_2$ and particulate nitrate) can contribute to excess nitrogen levels in ecosystems. These excess nitrogen levels can result in:

- Changes in plant and soil community species diversity.
- Altered community structure.
- Eutrophication in surface and coastal waters.
- Acidified soils and waters (see Chapter 2, Purer Water).

Airborne sulfur species (including the criteria pollutants $SO_2$ and particulate sulfate) can also contribute excess sulfur to ecosystems, which can lead to acidification of the soils and related effects. When deposited together, airborne nitrogen and sulfur species are known as acid deposition. (See the discussion of acid deposition in Section 1.2 of this chapter.)

Land and water can be contaminated by deposition of air toxics, leading to contamination of plants and animals and, eventually, of humans further up the food chain. Airborne mercury from incineration, for example, can settle in water and contaminate fish (see Chapter 2, Purer Water). People who eat fish are then exposed to mercury, which is known to be harmful to the nervous system.

No specific indicators have been identified at this time to address the ecological effects associated with outdoor air pollution. Additional discussion of the ecological effects associated with outdoor air pollution is found in Chapter 5, Ecological Condition.